Prediction Of Calving Interval And Survival Breeding Values For Foreign Bulls Without Daughters In Ireland

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Introduction

Poor cow fertility has been identified as a growing problem in Irish dairy herds. In this seasonal calving and the grass based production system, poor fertility results in a significant loss in farm income (Veerkamp *et al.,* 2001) due to forced culling or a shift in calving pattern. In order to arrest this trend, subsequent calving interval (CIV) and survival to the next lactation (SUV) has been introduced as objective traits in the dairy breeding goal, as measures of cow fertility and longevity (Veerkamp *et al*., 2001). Calving interval was chosen as a measure of fertility because of its relationship with direct measures of fertility, direct relevance in the seasonal calving production system and availability of data from milk records.

Because Ireland is, generally, an importing country with regards to dairy genetics, a high proportion of active AI bulls are foreign bulls with no milking daughters and hence no reliable domestic proofs. For example, about 45% of the 1,600 AI bulls available in Ireland in recent years were foreign proven bulls whose semen was imported and approved for widespread use. For these bulls, production proofs on the Irish scale were available immediately from the multiple across country evaluation (MACE) service of INTERBULL, however it will take about 4-5 years to produce a reliable CIV and SUV proof for these bulls based on their daughters in Ireland. Waiting that long before selecting bulls based on information on their genetic potential for fertility and survival will reduce progress and is therefore unacceptable given that some of these bulls have similar proofs in their country of first test.

Presently, national evaluations for fertility is carried out in The Netherlands, Germany, France, Denmark, Finland, Sweden and Czech Republic while longevity evaluation is carried out in almost all INTERBULL member countries. In the absence of an International evaluation service for longevity and fertility, similar to the one available for production and conformation traits, direct conversion of foreign proofs to Irish CIV and SUV equivalents seem to be the logical option. Variation in trait definition and methodology across countries with fertility and survival traits however imply that CIV and SUV will have to be predicted from different traits in different countries.

The aim of this study was to identify the traits from which CIV and SUV can be accurately predicted in different countries and to derive conversion equation.

Foreign country evaluation and proofs

Most countries produce breeding values for survival and include it in their overall selection index (VanRaden, 2002). This may be direct survival based on some measure of longevity or indirect survival obtained by including some predictors of direct survival. Predictors of survival in these countries include both production and conformation traits. Table 1 summarises the traits evaluated in each country to produce fertility and longevity type breeding values.

The Netherlands produce breeding values for durability (DU) by combining breeding values for functional lifespan (direct longevity) and breeding values for 6 predictor traits namely Rump angle, Teat placement, Udder depth Overall feet and Legs, Somatic cell count (log scale) and Interval from Calving to first Insemination. Their female fertility index is derived from breeding values for Non return rate at day 56 (NR56) and Calving to first service interval (CFI).

The United States of America currently has no official evaluation for female fertility. Breeding value for direct longevity is based on productive life (PL) obtained by BLUP using a single trait animal model. Indirect longevity is

derived from a MACE-like combination of breeding values for Milk yield, fat yield, protein yield, somatic cell score, Udder composite, Feet and Leg composite and body composite.

In **New Zealand**, longevity proof is estimated with a multitrait animal model. Survival analysis is used to derive 'life expectancy' for all right censored records. This is subsequently analysed jointly with the uncensored records (Harris & Winkelman, 2000). Fertility evaluation is based on analysis of 2 binomial traits -Ability to be presented for mating in the first 21 days (DFM) and ability to bear a calf from Artificial Insemination (CAI)- in the first 3 lactations. Breeding values are estimated by BLUP with a multiple (6) trait animal model.

Fertility proofs are currently not available from the **United Kingdom** but work is progressing, and they hope to have one in early 2003. The lifespan (or herd life) PTA is derived from a bivariate analysis of lifespan score and a phenotypic index of 4 linear type traits (Fore Udder Attachment, Foot Angle, Udder Depth and Teat Length) (Brotherstone *et al.*, 1998).

In **Denmark** breeding values for direct longevity is based on productive life and obtained by survival analysis. There is no separate proof for indirect longevity because all type traits eventually contribute to the overall index (S-index). The female fertility index is derived from weighted breeding values for NR56 for heifers, NR56 for cows, First to last insemination interval for heifers, First to last insemination interval for cows and calving to first insemination interval for cows. Heifer and cow traits are considered different and breeding values are obtained by multitrait BLUP evaluation using a sire model.

In **Finland,** female fertility is based on 2 traits analysed separately. These include; a) operational days open (DO) defined as traditional days open incorporating information on culled cows and b) fertility treatments (FT) i.e. veterinary treatments due to impaired fertility defined as a binary trait. DO is analysed with a single trait animal model while FT is analysed with a single trait sire model. The overall female fertility is obtained as a weighted combination (ratio 2:1) of DO and FT. Presently, Finland has breeding values for health traits but there is a plan to introduce a single longevity breeding values in the near future.

Germany has a reproduction (fertility) index comprising both direct paternal and maternal effects estimated simultaneously by BLUP with an animal model. Component traits include calving difficulties, stillbirth and non-return rate at day 90 (NR90). Longevity is based on evaluation of functional length of productive life (LPL) using the survival analysis technique.

Fertility evaluation in **Austria** is based on direct and maternal non-return rate using a multiple trait animal model. Survival evaluation has been based on functional length of productive life using survival analysis since 1995. Plans are in progress to evaluate this trait jointly with Germany in the future so as to increase accuracy (Fuerst & Egger-Danner, 2002).

Longevity evaluation in **Switzerland** is also based on the Length of productive life (LPL) defined as the number of days between the first calving and the last test day also using the survival analysis technique. There are plans to introduce evaluations for female fertility next year.

Italy evaluates productive lifespan (PLS) using survival analysis technique. The longevity proof is based on a combination of PLS and 2 predictive composite traits (Udder and Feet and Legs) using MACE methodology. There is presently no official evaluation for fertility in Italy.

Production adjusted length of productive life is evaluated in **France** using the survival kit with a sire-maternal grand-sire model. The fertility proof is estimated from analysis of a binomial trait that indicates success or failure of artificial insemination in virgin heifers and lactating cows. While measures in heifers and lactating cows are treated as different but correlated traits, conception following post *partum* AI in successive lactations is considered the same (repeated) trait across parities. Breeding values for both traits are estimated from a bivariate analysis with a sire and maternal grand sire model, which include the random effect of the service bull and PE cow effect for postpartum fertility. Only BVs for postpartum cow fertility are published.

Table 1. Fertility and survival traits evaluated in some INTERBULL member countries.

Country	Direct	Predictors	Model
The Netherlands			
Durability	Functional Life span	Rump angle, Teat placement, Udder depth, Feet and legs, Somatic cell count and Calving to first insemination interval.	Survival analysis functional life.
Female fertility index		Non return rate day 56 (NR56), Calving to first insemination interval (CFI)	ST SM
United States of America			
Longevity	Productive Life (PL)	Milk yield, Fat yield, Protein yield, Somatic cell score, Udder composite, Feet and Leg composite and Body composite	BLUP ST AM for PL, MACE to combine
Denmark			Survival analysis
Longevity	Productive life		
Female fertility		Non return rate day 56(heifers and cows) First to last insemination interval (heifers and cows separately) Calving to first insemination interval (cows only)	BLUP MT SM
New Zealand			
Longevity	Herd life		Survival analysis
Fertility		Presentation for mating within 21 days of calving (DFM) Bearing a calf through AI (CAI) Lactation 1-3	BLUP MT AM
UK			
Longevity	Herd life (Life Span Score)	Phenotypic index of type traits (Fore Udder attachment, Foot Angle, Udder Depth, Teat Length).	BLUP ST AM for LS Bivariate analysis to combine with index of type trait
Germany			
Longevity	Functional Length of Productive Life		Survival analysis
Fertility	Reproduction index	Calving difficulties, stillbirth and non return rate at day 90 (NR90) (Paternal and maternal effects)	BLUP, MT, AM
Italy			Survival analysis for PLS
Longevity	Productive life span (PLS)	Feet and Leg Composite Udder Composite	MACE to combine
Austria			
Longevity	Functional Length of Productive Life		Survival analysis
Fertility		Non-return rate at day 90 (NR90) (Direct and maternal effects)	BLUP, MT, AM
France			Survival analysis
Longevity	Functional length of productive life		
Fertility	Success to AI	Heifers, Cows	BLUP, MT, SM
Ireland Longevity Fertility	Survival to the next lactation (yes or No) for lactation 1 - 3	Milk yield, Angularity, Udder Depth, Body condition Score and Foot Angle	BLUP, MT, SM Combined single analysis for both traits

National evaluation in Ireland

Calving interval and survival breeding values were predicted for Holstein Friesian bulls with daughters milking in Ireland using a multivariate sire model. Traits evaluated included CIV, SUV and 305-day milk yield in the first 3 lactations as well as Foot Angle, Angularity, Udder depth and Body condition score (Pool *et al.,* 2002). Records in later lactations were included to improve accuracy of the previous evaluation based on first lactation records only (Olori *et al.,* 2002), while the linear type trait serve as early predictors. Breeding values for the 13 traits were obtained by BLUP using PEST (Groeneveld *et al.,* 1990). Survival was adjusted for production (milk yield) at the genetic level (Meuwissen *et al.,* 2002) to account for voluntary culling following which, breeding values for CIV and SUV were averaged across lactations.

Materials and Method

Derivation of conversion factors

Because of the variation in trait definition and evaluation method across countries, CIV and SUV equivalents in Ireland were predicted from different traits in different countries. National bull proofs for production and conformation traits as well as available functional traits were obtained from The Netherlands, France, New Zealand, USA, Denmark, United Kingdom, Switzerland, Germany and Italy. From each country file, AI bulls with proofs based on first or first and second crop daughters in country of origin were retained. Identification was based on the Interbull 'type of proof' and 'bull status' codes in the production (010) file. These were merged with the Irish data files to identify common bulls. For each country separately, at least 20 common bulls with a minimum reliability of 50% (30% for 1 country) for calving Interval and survival in Ireland were selected and used in a stepwise regression analysis to derive factors for predicting CIV and SUV from the most significant traits. Significance was judged by the statistical contribution of the trait to the model, similarity between countries, some logic and need for keeping the process simple with as few traits as possible in the model.

converted proofs = $constant + \sum_i b_i \; EBV_i$

where

b_i=regression coefficient for trait i and EBV_i = breeding value for trait I in the foreign country scale.

Correlation between countries

The genetic correlation between countries (r_{gc}) was approximated from the correlation between converted and home proofs. These were first corrected for the average reliability of the proofs (Calo *et al.,* 1973) from the home and foreign country for the set of bulls used in deriving the equations as follows:

$$r_{gc} = \frac{r_{ebv}}{\sqrt{rel_{irl} * rel_{for}}}$$

where

r_{gc} = approximate genetic correlation between Ireland and foreign country
r_{ebv} = multiple regression correlation between breeding values (estimated and foreign proofs)
rel_{irl} = average reliability of estimated breeding values in Ireland for the set of foreign bulls
rel_{for} = average reliability of breeding values for foreign country

Reliability of the converted proof was derived from the reliability of the component traits and the genetic correlation between the countries for that trait as shown in the equation above.

$$rel_c = \left(\frac{\sum_i (b_i w_i)^2 - \sum_i \left[(b_i w_i)^2 (1 - rel_i) \right]}{\sum_i (b_i w_i)^2} \right) * r_{gc}^{\;2}$$

where;

relc = reliability of converted trait, wi =genetic standard deviation of trait i in the foreign country and bi is the regression factor for trait I and reli is the reliability of trait I in the foreign country.

Blending of national and converted proofs

Where a foreign bull has a proof in Ireland based on it daughters, the Irish proof was official if the reliability is at least 50% otherwise, the national and converted proofs are blended using the following equation;

$$EBV_b = \frac{\frac{1}{(1-rel_{irl})} * EBV_{irl} + \frac{1}{(1-rel_{conv})} * EBV_{conv}}{\left(\frac{1}{1-rel_{irl}} + \frac{1}{1-rel_{conv}}\right)}$$

where

EBV_b = blended proof
EBV_{irl} = irish proof (based on daughters in Ireland)
EBV_{conv} = converted proof
rel_{irl} = reliability of the Irish proof
rel_{conv} = reliability of the converted proof

Results and Discussion

The number of common bulls eligible for deriving the conversion equations ranged from 35 (New Zealand, 15 NZL and 19 foreign) to 66 (USA). These were bulls with reliability of foreign proof over 85% and reliability of CIV & SUV in Ireland over 50% with the exception of New Zealand and Denmark where sufficient bulls with reliability of 50% or more in Ireland were not found. In these two instances, bulls with a minimum reliability of 30% in Ireland were selected. For NZL also foreign bulls included. Table 2 shows the traits used in predicting CIV and SUV from each country, the number of common bulls as well as the approximate genetic correlation between Ireland and the respective countries for each trait.

Table 2. Foreign country traits used in conversion equations for CIV and SUV and genetic correlation with Ireland.

Country	**Survival breeding value (SUV)**		**Calving Interval breeding value (CIV)**	
	Traits	**r_{gc}**	**Traits**	**r_{gc}**
The Netherlands (52)*	+ Durability[1] + Fert_index	0.66	- CFI calving interval to 1[e] insemination - Fert_index + Milk yield	0.95
New Zealand (34 [15 & 19))	+Longevity	0.87	- +Milk Yield -fertility +calving difficulty	0.96
France (26)	+Fertility	0.98	-Fertility +Milk yield	0.66
USA (66)	+Longevity +Udder Depth	0.57	+Milk Yield -Longevity	0.56
Denmark (21)	+Longevity -Angularity	0.87	-Female fertility +Milk yield	0.89
United Kingdom (52)	+Lifespan	0.78	-Lifespan +Milk yield	0.46

* Numbers in parenthesis are common bulls available for deriving the conversion equations.

The correlation between countries for calving interval ranged from 0.46 (UK) to 0.96 (France). Milk yield was useful in predicting CIV in all countries. The longevity proof was also useful for those countries without a fertility proof with the exception of New Zealand. Genetic correlations for CIV were lower (0.46-0.56) between Ireland and countries that had no fertility proofs compared to those with fertility proofs (0.66-0.96) in the conversion equation.

Approximate genetic correlation between countries ranged from 0.57 (USA) to 0.98 (FRA) for Survival. The Fertility index in France and the Netherlands were important in predicting Survival in Ireland. SUV was sufficiently and accurately

predicted from the French fertility index alone, which attests to the strong relationship between fertility and survival in Ireland. In France, virgin heifer fertility contributes indirectly to the postpartum fertility proof. The strong correlation between this trait and survival in Ireland tend to suggest that culling in the first lactation in Ireland may also be due to poor virgin heifer fertility. For example, a heifer that conceives very late in the breeding season is most likely to be culled during the first lactation, or not bred in the next breeding season so as to avoid mating it out of season, giving rise to a prolonged calving interval. Udder Depth was important in addition to longevity in predicting SUV from the USA while Angularity was important in Denmark.

There were either not enough common bulls, or the reliability of the proofs for available proofs were not high enough to facilitate derivation of conversion equations for Germany, Switzerland, Italy, Spain and Finland.

Publication of proofs

In computing the economic breeding value, CIV and SUV proof based on the daughters of a foreign bull were utilised if the reliability was over 50%. For bulls with lower reliability, the blended proof was used if a converted proof was also available. Otherwise, the converted proof was used and published. For bulls from countries were conversion equations are not currently available, a fixed value of -0.15% for SUV and 2.21 days for CIV was assumed. This was the mean for all foreign bulls for the countries with conversion equations.

Conclusion

This study has made it possible for calving interval and survival proofs to be predicted for bulls from 6 foreign countries based on fertility, longevity and production proofs in the foreign countries. Approximate genetic correlation where moderate to high between Ireland and all countries for both traits except fertility from the USA and the UK. This will hopefully improve with the launch of fertility evaluation in these countries.

Correlations with Denmark and New Zealand were high for both traits. These figures support the need for wider studies aimed at facilitating the introduction of MACE for fertility and longevity type traits.

Converted proofs from 2,245 bulls from the six countries were used to improve the Irish proofs through blending where the reliability of the foreign bull proof based on its few daughters would have been below publishable level otherwise. Many more active bulls had only converted proofs. This has allowed the Economic breeding Index to be computed more accurately for all bulls in Ireland hence selection of these bulls in Ireland can made with prior knowledge of their genetic potential for fertility and survival in Ireland based on their performance in related traits in the country of first test.

Acknowledgement

We are grateful to the officials of the Animal evaluation centres from The Netherlands, France, USA, Denmark, New Zealand, Germany, Italy, Switzerland, Spain, Finland and Great Britain for providing us with their data and information as well as to all others who responded to our request for data and queries. We would also like to thank all members of the project advisory group- Drs. E. Mantysaari, N. Gengler and S. Brotherstone for their contribution.

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